MANAV RACHNA INTERNATIONAL UNIVERSITY

Short Synopsis

For

Ph. D. Programme 2011-12

DEVELOPMENT OF IMAGE REGISTRATION ALGORITHM

DEPARTMENT OF ECE

FACULTY OF ENGINEERING & TECHNOLOGY

Submitted by:
SUNANDA
Registration No.11 / Ph.D/0018

Supervisor:
Dr. S.K. Chakarvarti
Professor & Assoc. Dean
Research & Development
Manav Rachna International University,
Faridabad, Haryana

Co-Supervisor:
Dr. Prof Zaheeruddin
Professor & Head
Department of Electrical Engineering,
Jamia Millia Islamia,
New Delhi

ABSTRACT

An image registration method involves the alignment of the two or more images of the same scene taken at different times, with different instruments, and from different viewpoints. In this process, two images (the reference and sensed images) are geometrically aligned in order to observe subtle changes between two images.

This research work aims at designing and development of an image registration algorithm to obtain the best alignment and correct registration for further fusion. The proposed method is expected to show very good performance in terms of time taken for registration, P.S.N.R (peak signal to noise ratio) and entropy. The effectiveness of the proposed method can be proved by comparative analysis of the proposed design approach with various techniques of image registration developed earlier. The four basic steps of the image registration procedure are: feature detection, control points matching, a design of the mapping function, and image transformation according to their nature (area based and feature-based).

The proposed method will be implemented using MAT lab language and tools. This proposed image registration method can be extended for multimodal or 3D image registration, which is presently very useful in medical diagnosis, etc.

Keywords: Image registration; MAT lab; Edge detection; Control points; Feature matching; Mapping function; Resampling; Area based registration.

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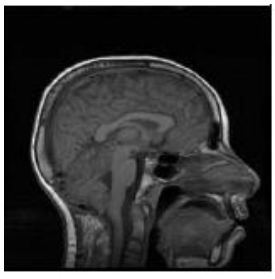
DEVELOPMENT OF IMAGE REGISTARTION ALGORITHM

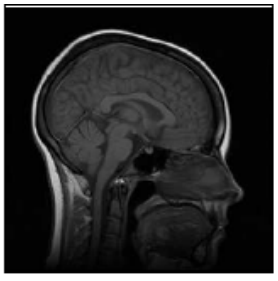
INTRODUCTION:

Image registration is one of the essential image processing applications of geometric transformation. It is used to find the correspondence between images of the same scene. Many image processing applications like computer vision, medical imaging, and remote sensing require image registration. It is a process of overlaying two and more images taken at different times, acquired by same or different sensors and from different viewpoints,. To register images, we need to find a geometric transformation function that aligns images with respect to the reference image (Zitova and Flusser, 2003). The transformations that occur due to image acquisition process are accounted during image registration and help us to discover the differences in the underlying scene. Registration is an essential pre-processing step which makes environmental studies possible using satellite images.

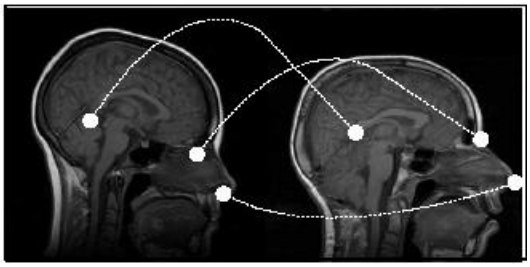
A large variety of image registration techniques have been used successfully for different types of applications to register unoccluded images. All or most of the pixels are valid in unoccluded images but invalid pixels occur in occluded images and participate in the registration process. Consequently, a false registration is generated as these invalid pixels convey information as if they were valid.

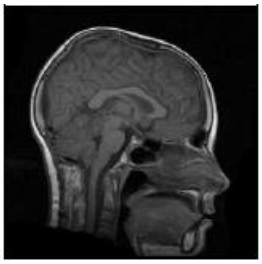
So “Image registration” is an essential as well as a fundamental step in image processing. Virtually, image registration techniques are used as intermediate step to evaluate images in all large image analysis systems. At first, the correspondence between pixels of sensed image and the reference image is found. This leads to obtain a correspondence function which is the main objective of the image registration. After obtaining the Transformation or mapping function, the sensed image may be brought into registration with the referenced image as shown in the Fig.1.





(a) Sensed image (b) Reference image





(c) Corresponding points (d) Registered image

Fig.1(a-d): Process of Image Registration

Fig1(a) and Fig1(b) show the sensed and reference images. Fig1(c) shows the corresponding points between sensed and reference images. Fig1(d) shows the registered image obtained by warping the sensed image by correspondence mapping.

LITRATURE REVIEW:

Image registration is the most important geometric transformation application of image processing. Image registration is used to establish correspondence using features of two or more pictures. Basically, registration is a process to transform different set of data in one coordinate system. In the literature review, various techniques and methods of image registration for corner detection, edge detection and affine transformation have been studied.

In 1998, Zhao and Yuna proposed a new affine transformation to improve the compression fidelity. The proposed affine transformation is practically used in image coding. A new transformation is proposed to improve the image quality. They also analyzed the requirement of its contractivity and derived the new optimal parameters. This technique is compared with many available fractal coding techniques and results show the efficiency improvement in the quality of reconstructed images. All the results are based on peak signal - to - noise ratio and compression ratio parameter.

In 2004, Li and Heung used an exact maximum likelihood registration method. This method depends on the control points and the intensity values of the image for image alignment. Cramer-Rao Bound (CR) formulas are also derived to check the performance of this image registration technique and affine transformation parameter are used for image alignment. An maximum likelihood method is developed to estimate the registration parameter and CP

(control point) coordinate in a recursive fashion. The maximum likelihood approach has a wider application than the conventional control point (CP) and intensity based method. When both CPs and intensity are available, the accuracy of the proposed maximum likelihood registration method is higher than CP based and intensity based approaches. This method can also be used to align images when either intensity or CPs is not available.

In 2006, Riyamongol and Zhao proposed the Hopfield neural network model. This model uses the correlation method to give the solution of affine transformation parameters. In this paper, the adaptive cross correlation method is also implemented. The corresponding pixels between two images are found from correlation method. The new affine transformation parameters are calculated from the corresponding pixels. These affine transformation parameters are then used to register the images. The mean square error is found from the derived affine transformation equation. This equation is then combined with the energy function. It is shown that the mean square error is minimized at local minima of the energy function. The output of this model would be affine transformation parameters that are used to register the images.

In 2006, Kadyrov and Petrou proposed a methodology to recover the parameters of the affine transformation for images which may be affinely distorted due to various effects such as occlusion and illumination variation. This method is also applicable for matching two images that do not depict the same scene or object. In general, images differ from each other by more complicated transformation. In order to recover the affine transformation, the trace transform method is developed, which is used to register images which are not affinely transformed version of the same object.

In 2007, Awrangjeb and Lu proposed a corner matching technique that is based on affine transformation parameter. Feature matching techniques are based on two categories. In the first category, neighborhood pixel corner matching is performed. The second category relates to intensity information or the curvature matching of images. With this technique, the corners are detected by contour-based detector. The position, affine length and absolute curvature value are calculated for each corner. This procedure uses minimum curvature difference to find at least three corner matches so as to calculate the affine transformation parameters. This

technique exploits the affine length invariance between corners on the same curve. It also makes use of the absolute curvature value which remains unchanged or sometimes changes slightly during affine transformation.

In 2009, Holia and Thakur described an algorithm to determine affine transformation parameters using the Nelder Mead simplex method. Translation parameters from two or more images having translation, rotation, scaling difference are recovered. It is also known as similarity transformation. These images are registered using a correlation minimization function with the Nelder Mead method. In this method transformation parameters are applied on sensed image to achieve maximum correlation between the sensed and original image. This technique is used for images which are misaligned due to small transformation, but taken from the same sensor.

In 2010, Park and Martin developed a new method that is also based on affine transformation. This technique determines the transformation parameters which map pixel from one image to another and enables the comparison of images acquired from different viewpoints. Misalignment of images can be corrected using these parameters. In this method affine estimator is described. This estimator is based on Fourier slice analysis and Fourier spectral alignment. It shows the performance parameter in terms of speed and accuracy. This method requires fast computation and high reliability. The advantages of the proposed method are the capability to estimate the full affine transformation and reflection symmetry accurately.

In 2010, Lin and Zhao developed an automated image registration method. A new image registration algorithm based on affine transformation model and corner detection is used to solve the shifting transformation. At first, the corner features were extracted by Harris operator, and then image edge detection was conducted by the Canny operator (Canny, 1986). This method can be used to achieve better registration between two or more images which have difference in shifting, scaling and rotation. This algorithm is very simple, has low computational complexity and is more reliable.

In 2010, Gillon and Agathoklis developed a new technique to find out a set of feature points between two or more images and use these feature points for image registration. In feature based methods, feature points of an image are extracted to determine correlation of areas between two similar images and then the parameters of transformation are obtained. This technique is based on Mexican-hat wavelet for feature extraction, on the magnitude of Zernike moments for finding the correspondence between points in the two images and on iterative weighted least square minimization algorithm to provide the transformation parameter. This method deals with the images having different scales and affine distortions.

DESCRIPTION OF BROAD AREA:

1. IMAGE REGISTRATION PROCESS

As mentioned in the Introduction, Image registration is widely used in computer vision, remote sensing, medical imaging, etc. Depending upon the image acquisition process, image registration can be divided into the following categories (Zitova and Flusser, 2003):

(a) **Multiview analysis**: In this kind of analysis pictures of the same scene are taken from different viewpoints, e.g. mosaicking of images of the surveyed area.

(b**) Multitemporal analysis**: In this analysis, images of the same scene are acquired under different conditions at different times, e.g. landscape planning, monitoring of the healing process of a single patient (like tumor growth).

(c**) Multimodal analysis**: Pictures of the same scene are taken by different sensors in multimodal analysis. The objective is to enhance the visualization of the scene, e.g. two medical images of a patient may be a PET and MRI scan.

As the technology is developing very fast these days, today's latest technology may become obsolete tomorrow. So there is a lot of diversity and degradation of images to be registered. Therefore, a single method of registration cannot be used for all kinds of images to be registered. Every method is developed for a special kind of images. Generally the image registration process consists of the following steps:

1.1 Detection of features

A feature is any portion of the image which can be identified and located easily in both images. This feature can be a point, line and corner. Identification of features can be done manually as

well as automatically. These features are represented by their point representation and are called control points. Basically, there are two main approaches for feature detection:

1.1.1 Feature based methods

These methods are also known as point based methods. In this approach important features are extracted by using feature extraction algorithms. Important regions (fields, lakes,), lines (roads ,region boundaries and rivers) and points (points on intersecting lines, region corners points) are taken as features here. It should be assured that selected features should be found uniquely, efficiently detectable in both images.

It is also ensured that features are uniformly spread all over the image. They are more tolerant to local distortions (Zitova and Flusser, 2003). It is expected that features are invariant means stable in time to remain in fixed positions. Feature based methods are used for images having large intensity variations.

Projections of regions of closed boundaries of appropriate size and high contrast (Goshtasby et al., 1986; Flusser and Suk, 1994), water reservoirs, lakes (Goshtasby and Stockman, 1985; Holm, 1991), buildings (Hsieh et al., 1992), forests (Sester et al., 1998), urban areas (Roux, 1996) or shadows (Brivio et al., 1992) are generally considered as the region-like features. Segmentation methods are used to detect region features (Pal and Pal, 1993). The resulting registration accuracy is influenced by the accuracy of the segmentation. Now a days, emphasis is also given to select invariant region features that do not change with a change of scale.

Most commonly used line feature detection methods are Canny detector (Canny, 1986) or Laplacian of Gaussian (Marr and Hildreth, 1980).

The point features group comprises the approaches working with line intersections (Stockman et al., 1982; Vasileisky et al., 1998), road crossings (Roux, 1996; Growe and Tonjes, 1997), centroids of water regions, and corners (Wang et al., 1983; Hsieh et al., 1992; Bhattacharya and Sinha, 1997).

Computational time necessary for the registration increases with the number of detected points increases. There are several methods available to detect relatively lesser number of feature points without degrading the quality of registration method.

1.1.2 Area based methods

Area based methods are often used for template matching in which the orientation of template is found in the reference image. Feature detection done at first step is removed in the Area based methods.

1.2 Corresponding features matching

Once the features are detected in reference image and sensed image, they need to be matched respectively using the spatial relationship between the features. Image intensity values can also be used to match detected features in their closest neighborhood.

1.2.1 Feature based methods

As we know that detected features are called control points in both sensed and reference images, in feature matching step, therefore, the pairwise correspondence is calculated between detected features using their spatial distribution or their different descriptors of features.

Spatial relations based methods are used when there is an obscure information about the detected features . The information about the spatial distribution and the distance between the control points is exploited. Goshtasby and Stockman, (1985) proposed the registration method based on the graph matching algorithm. Stockman et al., (1982) in their paper developed a Clustering technique to match control points.

Estimation of correspondence of features using their description is an alternative approach to methods exploiting spatial relationships. The selection of the type of the invariant description depends on the assumed geometric deformation of the images and the feature characteristics. The minimum distance rule with some threshold value is generally applied to match feature pairs in the space of feature descriptors. The matching likelihood coefficients (Flusser, 1995) are appropriate for better handling of questionable situations and is a more robust algorithm solution. Guest et al. (2001) demonstrated the selection of control points based on their possible matches reliability.

The image intensity function itself is the simplest feature description (Abdelsayed et al., 1995; Lehmann, 1999). The Cross Correlation is computed to estimate the feature correspondence on these neighborhoods.

Ventura et al. (1990) used a multi value logical tree to represent relations among image features followed by finding the feature correspondence after comparing the multi value logical trees of the reference and sensed images. Brivio et al., (1992) also applied multi value logical trees together with moment invariants.

1.3 Estimation of geometric transformation

After establishing the feature correspondence, Geometric transformation function ,also known as mapping function, is constructed. The Geometric transformation function maps the features of one image onto the locations of matching features in sensed image. Generally, a particular parametric transformation model is chosen depending upon the capture geometry of sensed image. Some methods estimate mapping function parameters while searching correspondence between features, thus combining this step with previous i.e. the second step. Sensed image should be transformed to be an overlay of the reference one.

Depending upon the amount of image data mapping functions, models of mapping functions can be classified into two broad categories.

1.3.1 Global models

These kinds of models use all the control points to estimate only one set of mapping functions, which is used for the entire image. Similarity transform is the simplest global model. The most common transformations are rotation, shear and scaling. Transformation is a mapping from one vector space to another, consisting of a linear part, expressed as a matrix multiplication, and an additive part expressed as an offset or translation. For mathematical and computational convenience, the transformation can be written as

T= [x y 1] [w z 1],

where T is affine matrix (transformation matrix).

1.3.2 Local models

In this type of modeling, the image is broken into a number of parts and each part is considered a separate image. Also the parameters of mapping function are defined for each part separately. The superiority of the local registration methods over the global ones is shown by Goshtasby (1988); Ehlers and Fogel (1994); Wiemker et al. (1996) and Flusser (1992).The local model methods are also called piecewise linear mapping (Goshtasby, 1986) and piecewise cubic mapping (Goshtasby, 1987).

1.4 Resampling image

Mapping functions estimated above are utilized directly to transform each pixel of the sensed image and then to register the image. It is also known as forward method approach, but difficult while implementing. It also produces holes and overlaps in the output image due to the discretization. As an alternative, another approach, called the backward approach, is

normally used. In this approach, the image interpolation takes place in the sensed image on the regular grid.

2. EVALUATION OF IMAGE REGISTRATION ACCURACY:

Any registration algorithm cannot be utilized for real world application until it is evaluated for its accuracy. Therefore determination of the accuracy of registration algorithm is the essential part of image registration methods. To evaluate the registration accuracy some basic classes of error and techniques are listed below.

Localization error

A localization error occurs due to inaccurate detection of control points which results in a displacement of the control point coordinates. An 'optimal' feature detection algorithm is selected for a given set of data to minimize the localization error but there should be a tradeoff between the mean localization error and the number of detected control points because in some cases more control points with higher localization error are preferred over few control points detected precisely.

Matching error

A matching error occurs due to false matches done during establishing the correspondence between control points. In practice, it is measured by the number of false matches done during the registration process. This error can also cause the failure of the registration process. Therefore, it should be treated carefully and may be identified by consistency check. There are robust matching algorithms available to ensure robust matching.

Alignment error

Alignment error is the difference between the actual geometric distorted image and mapping model used for the registration. This error can be analyzed in many ways. Generally mean square error method at the control points is used. This method, however, quantifies only how well the control points are fitted in a mapping model derived earlier.

OBJECTIVES:

There is a lot of diversity and degradation of images to be registered. Therefore a single method of registration cannot be used for all kinds of images to be registered. Every method is developed for a special kind of image. This is one of the most fundamental issues underlying the design of image analysis.

Problem Formulation: Automatic image registration [Lin & Zhao ,2010] gives the better results by adopting corner neighborhood correlation matching on the edge map and affine transformation. Control point selection for affine transformation is carried out on the edge map, but the problem is that if edge map is not correctly deformed then the affine transformation will not give the better result.

There are advantages and limitations of every method. Hence it is essential to find the best algorithm or the best possible combination of methods of a registration process.

Thus, based on the past work, the following objectives are proposed for this research work:

- To study various techniques & analysis of the image registration methods.
- To study edge techniques to find the corner and boundaries in image registration system.
- To develop and design an image registration algorithm so that best alignment is obtained and correct registration is performed for further fusion.
- Reduction in time for image registration, such that either they matched for features or area results in quick and accurate results.
- To compare the quality metrics based on the result of the earlier and proposed method to obtain P.S.N.R and entropy.
- These image registration methods can be extended for multimodal or 3D image registration, which is presently very useful for medical diagnosis, etc.

Language and Tools: To implement this method we will use MAT lab language and tools.

METHODOLOGY:

In the new methodology, our main aim is to find the best edge map so that the reference image will be correctly achieved. The edge map provides the difference in scaling, rotation and translation. This difference will be minimal if the edge map is clearly detected in the reference image. On the basis of affine transformation parameter ,we will find the best result for better registration in terms of transformation and then the outcome of this method will be compared with the traditional methods. In order to do this, we have the following steps:

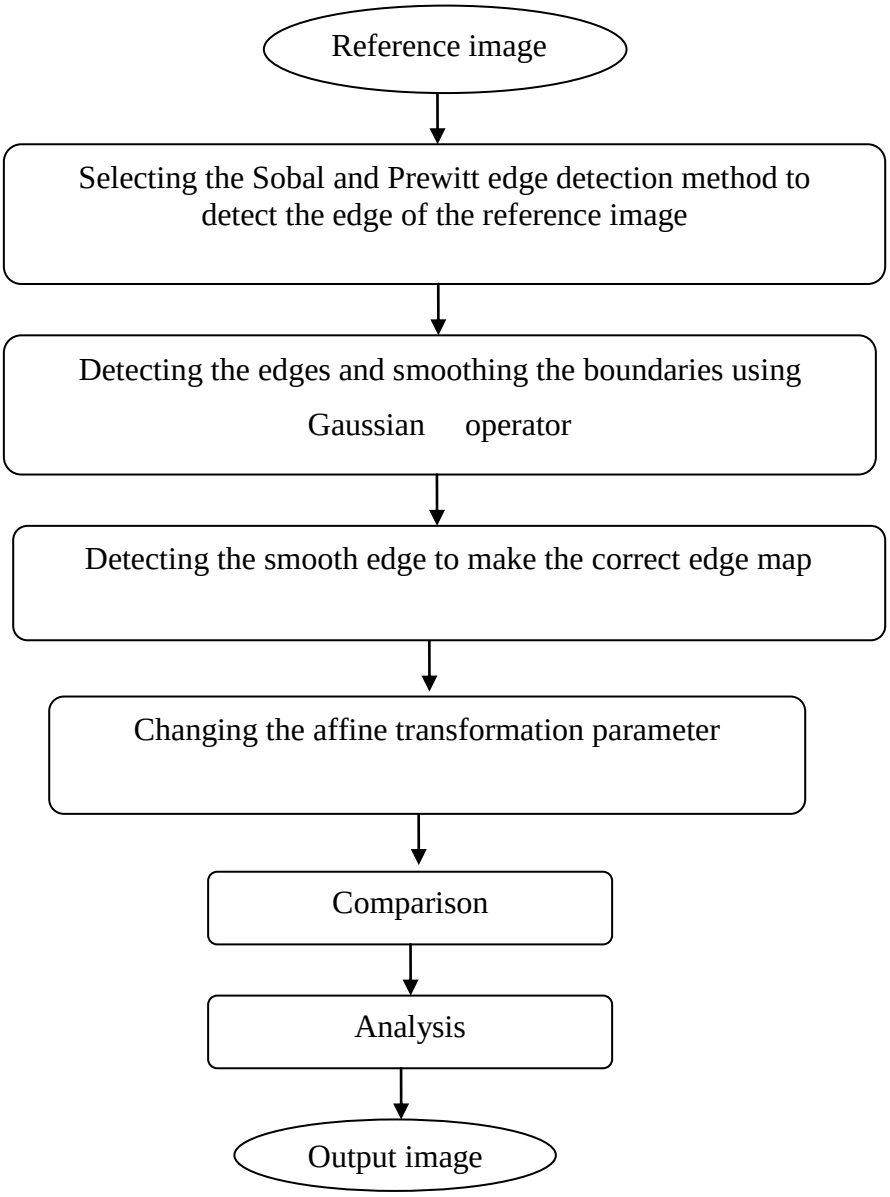

Reference image
Selecting the Sobal and Prewitt edge detection method to detect the edge of the reference image
Detecting the edges and smoothing the boundaries using Gaussian operator
Detecting the smooth edge to make the correct edge map
Changing the affine transformation parameter
Comparison
Analysis
Output image

Fig. 2: Showing the steps described in the methodology

One of the primary uses of registration is to account for the transformations that result from the image acquisition process so that differences in the underlying scene can be discovered.

After achieving good automatic registration for two or more images which have different rotation, scaling, shifting and different field of view, the main focus is to achieve the best edge map. For better registration, correct prediction of edge map is very important.

In this work, we would explore the correct edge map detection method with respect to affine transformation parameter for any reference image. That way we would achieve the good edge detection and the automatic selection of various parameters and their optimization.

Proposed Time Frame (Research plan):

Research Plan

	Sem1 (June'12)	Sem2 (Dec'12)	Sem3 (Dec' 13)	Sem4 (June'14)	Sem5 (Dec'14)	Sem6 (June'15)	Sem7 (Dec'15)	Sem8 (June'16)
Course work								
Literature Review								
International paper presentation and publication								
Data collection								
Data study								
Interpretation of data								
Thesis submission								

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